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REMARKS ON THE CRETACEOUS AND TERTIARY FLORA OF THE WESTERN TERRITORIES.

BY LEO LESQUEREUX.

THE following notes were suggested by two valuable communications to *Nature*, in the numbers bearing date June 30 and October 6, 1881; the first, that of Dr. J. S. Newberry, tending to show that the flora of the Dakota group, together with that of the Laramie group, are of Cretaceous age; the second, that of J. Starkie Gardner, Esq., of London, contending to the contrary, that both those floras are Tertiary.

As there is not any fixed characters admitted as standard points of determination of the age of a fossil flora, phytopalæontologists have no means of coming to an understanding on the subject, except by a comparison of the vegetable remains of the divers formations with those of localities whose geological horizon has been ascertained.

I take here, for comparison with the plants of the Dakota group, the Upper Cretaceous flora of Groenland, Atane; that of Moletin, of Quedlinburg, of the Quader-sandstone of the Hartz and other localities of Germany where this formation, generally considered as Middle Cretaceous, or Cenomanian, has been observed.

One hundred and seventy specific forms of plants are now known from the Dakota group; they represent six ferns, one Equisetum, or seven cryptogamous acrogens; seven Cycadeæ, ten conifers, three monocotyledonous plants; the others, about one hundred and fifty, all dicotyledonous angiosperms.

As far as known until now, the flora of Atane, Groenland, is represented in sixty-three species—thirteen ferns, two Cycadeæ, ten conifers, three monocotyledonous, while thirty-four, or a little more than one-half, are angiosperms.

The relation of the Atane flora with that of the Dakota group is marked by ten identical species: one fern, two conifers and seven dicotyledonous; while quite as distinct an affinity is demonstrated by allied types of the genera Ficus, Sassafras, Diospyros and Sapindus.

The flora of Quedlinburg is composed of twenty species; four ferns, four conifers, one monocotyledonous, with eleven angiosperms, a little more than half of the species. Of this group of plants, the relation to the flora of the Dakota group is shown by only one identical species, a fern, which is also found at Atane and Moletin, while analogy is marked by two species of Myrica and a Proteoides.

Moletin, in eighteen species described of its flora, has one fern, four conifers, one monocotyledonous and twelve angiospermous plants, these, therefore, constituting two-thirds of the flora.

Though the number is small, the flora is related to that of the Dakota group by identity of one fern, one conifer, both also recognized at Atane, and of two dicotyledonous species. This is a remarkably close relationship indeed, more intimate than that between the Quedlinburg and Moletin floras, and it is positive, for the species indicating it, *Gleichenia kurriana, Pinus quenstedti, Aralia formosa* and *Magnolia speciosa*, all described by Heer, are of easily identifiable characters.

The quader-sandstone of the Hartz is, by its numerous species of Credneria, related to the no less numerous representatives of the genus Protophyllum of the Dakota group.

In the Monde des Plantes, by Saporta, the author, who has had opportunity to compare specimens of plants of the Cenomanian of Bohemia with those of the more common and characteristic species of the Dakota group, remarks, p. 202, that the flora of this group presents, if not identical species with those of Bohemia and Moravia, at least a number of equivalent forms.

Mr. Feistmantel says, in a note to Professor Heer,[1] that the lower division of the Cretaceous of Bohemia (Perutzer-Schichten) is Cenomanian. After naming a number of plants found in the sandstone of this formation, he adds that the beds of shale, partly between, partly above the sandstone, contain remains of plants, ferns, conifers and a mass of dicotyledonous leaves and fresh-water shells. Of the forty-nine species determined by him, nine are also at Moletin, seven at Niedershoena, while three ferns and conifers are present in the Lower Cretaceous of Groenland, and four in the Upper, that of Atane. Of the same plants the Dakota group has five, positively identified: *Gleichenia kurriana, Pinus quenstedti, Sequoia Reichenbachi, Magnolia speciosa* and *Aralia formosa.* A sixth might be added, *Sequoia fastigiata*, but its identification is less definite. And still with the flora of Niedershoena, that of the American Cretaceous is related by one identical species, and the affinity of character of a Pterophyllum, a Caulinites, a Fagus, two species of Ficus, a Myrica and a Daphnogene.

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[1] Fl. Arc., Vol. III, p. 3.

To set aside the evidence derived from the remains of plants indicating synchronism and Cretaceous age of the localities above named, it may be said, as it has been done for the Laramie group, that vegetable remains are not sufficient authority for the determination of the age of a formation.

But here the determination of the formation from where the remains are derived, has been first made, or later confirmed by the characters of animal remains found in the intercalated or superposed strata. Heer states that the Moletin formation is positively referable to the quader-sandstone, Cenomanian, overlying the planer of Reuss referred to the Turonian; and of that of Quedlinburg, he states that it is referable to the lowest zone of the *Belemnitella quadrata*, which constitutes the lowest stage of the Senonian or Upper Cretaceous. In the quader-sandstein of the Hartz, from where the Credneria species have been obtained, a large number of animal remains, mostly of invertebrate and fishes, have been found. Stiehler, in his Beiträge,[1] quotes a long list of these genera and species, all Cretaceous. It is the same with the animal remains found in the strata overlaying the Dakota group in a space of more than two thousand feet.

The objection by Mr. Gardner is, that these so-called Cretaceous animal remains may not or are not generally or specifically identical with those of the Middle Cretaceous of England. Of this I am unable to judge. But it is said also that the vegetable types of the Dakota group appear too young to represent a Cretaceous formation, for some of them are closely related to plants of the Miocene. This is true, as it will be seen here below; but that cannot be taken into account in the discussion, for the relation is quite as prominent, rather still more marked with species of the present vegetation of North America, where a number of types of the flora of the Dakota group are reproduced in some of the more important and beautiful trees of our forests. This is the more remarkable that the affinity is not at all observable with the plants of the Lower Tertiary or Eocene of the Laramie group. But this refers to the second part of the discussion; before coming to it there are still a few words to say on the present objection.

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[1] Beiträge zur Kentniss der Vorweltlichen Flora, 1857.

The Lowest Cretaceous flora of Groenland, that of Come, is composed, as far as known, of seventy-five species, of which forty-two represent Cryptogamous acrogens, ferns, Lycopods and Equisetaceæ; nine Cycadeæ, seventeen conifers, six monocotyledonous and only one dicotyledonous angiosperm plant. Composed as it is, the group has rather the character of a Jurassic than of a Cretaceous flora. It is, however, related with Atane by five identical species, three ferns and two conifers, and also by that first or more ancient dicotyledonous plant, a Populus of the same type as three other forms of this genus described from Atane.

What conclusions can be derived from the above? The character of the flora of Come being Jurassic, the formation which it characterizes cannot be considered as Tertiary. Heer thinks even that the true Cretaceous begins with the flora of Atane. But admitting Come as lowest Cretaceous, we may follow the relation of its flora through Atane, not only with the Dakota group, but with all the formations mentioned above from Germany—Quedlinburg, Moletin, the Quader-sandstone and others; and, therefore, to admit the Dakota group to the Tertiary, it would be necessary to erase from the Cretaceous, as it is constituted, the whole of the formations related to it with Come, or the whole of the formations where angiospermous plants have been found.

On the second question considered in the memoirs of Mr. Starkie Gardner and Dr. Newberry, or the relative age of the Cretaceous and Lower Tertiary formations of North America in comparison with those of England, I have to omit the facts derived from animal palæontology. I can only briefly remark on the affinity and disparity of some vegetable types of the Dakota group compared to those of the American Eocene (the so-called Laramie or Lignitic group); of the Miocene of Carbon, and on the relation of the plants of the Lignitic with those of the Eocene of England and France.

From what is known until now of the plants of the American formations named above, the flora of the Dakota group is, as said already, more distinctly related by analogy and identity of species to that of the Miocene than to that of the Lignitic. Except the close affinity remarked between *Cinnamomum Heerii* (U. S. Geol. Rept., VI, p. 84, Pl. XXVIII, f. 11) and *Cinnamomum affine* (same Rept., VII, Pl. XXXVII, f. 1–5, 7), I do not know of any Cretaceous species which can be pointed out as indicating a distinct relation to plants of the Laramie group. Leaves of Cinnamomum have been described by Dr. Newberry from the Orcas island (Descriptions of fossil plants collected by Mr. G. Gibbs) and supposed by the author to be referable, partly at least, to *Cinnamomum Heerii*, described first from Vancouver's island. The author's remark, that the specimens, though typically allied to *Cinnamomum Scheuchzeri and C. lanceolatum*, indicate a larger and thicker leaf, confirms his supposition; for *Cinnamomum Heerii*, of which a fine specimen, preserved entire, has been obtained this year in Kansas for the Museum of Comparative Zoölogy of Cambridge, merely differs from *C. affine*, found at Golden and Carbon, by its more rounded base, both species being represented by leaves equally large and subcoriaceous. This form, therefore, passes to the Miocene through the Eocene without apparent modification. Of smaller leaves described from specimens of the Dakota group as *Cinnamomum Scheuchzeri*, a species of which two fine specimens have been also procured this year in Kansas, none have been seen in the plants of the Lignitic. The ferns of the last group also are without analogy to those published by Heer and myself from the Dakota group. The same can be said of the conifers, except *Abietites dubius*, which according to Saporta, has, by the scars left by the base of the leaves upon the stems, some analogy with Cunninghamites, a Cretaceous type. In the monocotyledonous, the palms especially, in the angiosperms the types of Populus, Platanus, Quercus, Ficus, Laurus, Viburnum, Rhamnus, Juglans, etc., all appear without relation to any of those of the Dakota group. Per contra, when comparing the plants of this Cretaceous formation with those of the Miocene of Carbon, even of the Pliocene of California, we find closely allied types, even identity of characters in species of Salix and still more in those of Populus. For example, between *Populus elliptica* Newby., Illustr. of species, Pl. III, f. 1–2, of the Dakota group, and *P. cuneata* Newby., *ibid.*, Pl. XIV, f. 1–4, of the Union group, no possible difference is found in the shape, size and nervation of the leaves. In the Cretaceous species, the borders are a little more distinctly crenate-serrate. But such a difference is of no account in leaves of the same type as the polymorphous *Populus arctica*, whose borders are entire or undulate, or more or less deeply serrate-crenate. Liriodendron and sassafras, not at all represented in the Laramie, are found in the Miocene, especially in that of Europe, in remarkably similar forms of leaves. Even *Liriodendron giganteum* of the Dakota group, considering the leaves only, is reproduced in *L. tulipifera* of the present North American flora. The same observation can be made on Fagus and Quercus, in comparing *Fagus polyclada* and *Quercus primordialis* of the Cretaceous, which without representative in the plants of the Laramie group, have species of similar type in the Miocene and also in the flora of this epoch. The Cretaceous *Platanus primæva* is comparable to the Miocene *P. gulielmæ,* while of the types of Aralia, so remarkaby abundant in the Cretaceous of Kansas, two are found at Carbon and Evanston, and none in the Lignitic. *Aralia quinquepartita,* figured U. S. Geol. Repts., VII, Pl. XV, f. 6, and still from better specimen, Vol. VIII (ined.), Pl. VII, f. 4, is reproduced in *Aralia augustiloba* of the Pliocene (gold gravel formation) of California. More of this same kind of analogy could be given, but the above is sufficient to prove that the characters of the flora of the Laramie group, or Eocene, greatly differ both from those of the Cretaceous and of the Miocene of this continent.

That they are related, and some of them positively identical with those of the Eocene of Europe, is remarked by Dr. Gardner, who has found in the Eocene of England, among a number of ferns, two species identified in the flora of the Laramie group. The table in the U. S. Geol. Repts., Vol. VII, p. 314, etc., indicates the relation of the plants of the Lignitic with those of different formations and localities as it was known when the volume was published. With the flora of Sezane, for example, the affinity is marked by twenty-one species. Since then a new kind of palm Ludoviopsis, obtained at Golden, indicates affinity to a species of Sezane, and another that of a finely preserved dicotyledonous leaf, figured in the same volume, Pl. XV, f. 5, is recognized by Saporta as identical to one of his species of the same locality, *Sterculia modesta,* thus increasing in a remarkable degree, the evidence of the relation of the flora of the Laramie group with that of the Eocene of Sezane.

But the review and discussion of the data concerning the Tertiary age of the Lignitic may be now of little importance, as all the phytopalæontologists who have entered into the discussion, have recognized the Tertiary characters of its flora. For it is evident that a number of the species described as Miocene by Dr. Newberry from the Fort Union group, are identical with those abundantly represented at Golden. If this fact has not been acknowledged by the eminent geologist of New York, the cause is most probably due to the mingling of the specimens submitted to him, which, derived from divers localities, were representatives of two formations, but were labeled as from the same locality, as would be, for example, the specimens of Carbon mixed with those of Golden, or those of Washakie mixed with those of Black Butte. A lot of specimens sent to me by the U. S. Geol. Survey, and labeled Point of Rocks, were certainly obtained from the Washakie group, as all represent Miocene species without analogy to those collected later by Dr. Hayden at Point of Rocks. This supposition only can explain the aggregation in the same geological group, of species like *Taxodium occidentale*, the large palms, *Sabal Campbelli*, the remarkable leaves of *Platanus Haydeni*, *P. Raynoldsi*, *Tilia antiqua*, etc., with such positively Miocene plants as *Sequoia Langsdorffi*, the forms of Populus allied to *P. arctica*, even species of our time, *Onoclea sensibilis*, *Corylus Americana*, *C. rostrata*, etc. All this gives to the Union group an evident Miocene facies, and therefore, from this consideration only, and in substituting Miocene for Tertiary, it would be possible and right to say, that no Miocene plant has been found in the Laramie group.

On the identity of some of the species of plants of the Union group with those of the Laramie, there is no possible doubt. The most abundant remains procured at the Raton mountains, by divers explorations, represent *Sabal Campbelli*; some of the finest specimens procured at Golden are of *Platanus Haydeni* and *P. Raynoldsi*. Some large pieces of sandstone, procured at Golden for the Museum of Princeton College, represent both the species figured in the illustrations of Dr. Newberry, Pls. XIX and XXI. And as all the specimens I have described from the collection made by the Geological Survey of Dr. F. V. Hayden, are now deposited in the National Museum, the determination of the species can be there critically examined.